

Advancing cooperation and research

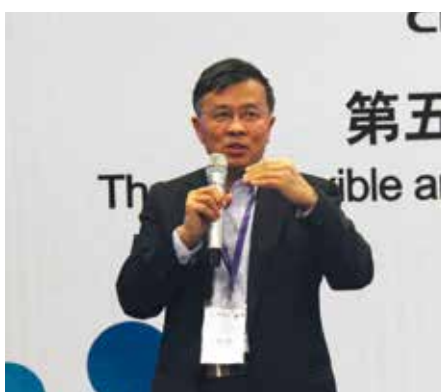
In an exclusive interview with OPE journal, Prof Zheng Cui of the renowned Chinese institute SINANO talks about his latest research in organic and printed electronics technology

OPE journal: Mr Cui, you are director of the Printable Electronics Research Center at the Suzhou Institute of Nanotech and Nano-Bionics. Could you shortly outline the research work and focuses of this institution? What role does printed electronics play in its research activities?

Zheng Cui: The Suzhou Institute of Nanotech and Nanobionics (SINANO) is one of over 100 research institutes under the umbrella of the Chinese Academy of Sciences (CAS). One could say that CAS is like a combination of the Max Planck Society and the Fraunhofer Institutes in Germany. The institutes within CAS include both fundamental and applied research. SINANO focuses on applied research, particularly in the areas of nanotechnology and nanobiological/medical research.

Moreover, SINANO, which was set up in 2006, belongs to a new breed of research institutes within CAS, which is funded jointly by the local government and the Suzhou Industrial Park. Its central task is to conduct research with the end goal of developing industrial applications. The transfer of technologies developed at SINANO to the industry is highly encouraged and supported. There are three major directions of R&D at SINANO. Printed electronics is one of them, with the other two being carbon nanomaterials and III-V semiconductors.

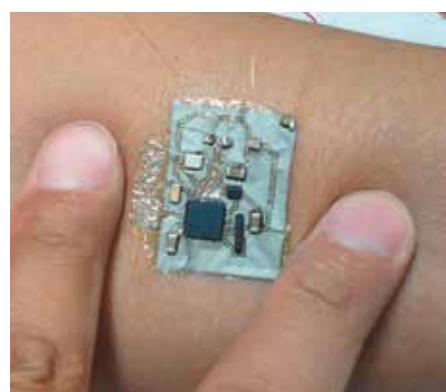
OPE journal: One of the biggest projects in your career was the creation of the Printable Electronics Research Center (PERC) at SINANO. What is the aim of this institutions and what are some landmark achievements in its history?



Zheng Cui

Z. Cui: I set up the Printable Electronics Research Center after my return to China in October 2009. At that time, there was no such centre in China, and PERC became the first of its kind. We started R&D for printed electronics in China truly from scratch. The aim of PERC is to fill the gap between China and the rest of the world in terms of PE development. As we were the first in China to dedicate our effort to PE, we planned from the very beginning to cover the entire PE technology chain. We have now built up a research team of more than 60 members with half of them as staff and the other half as research students. Thanks to the financial support from CAS and the local government, we have built a number of laboratories totalling 2500m² and \$4M worth of equipment.

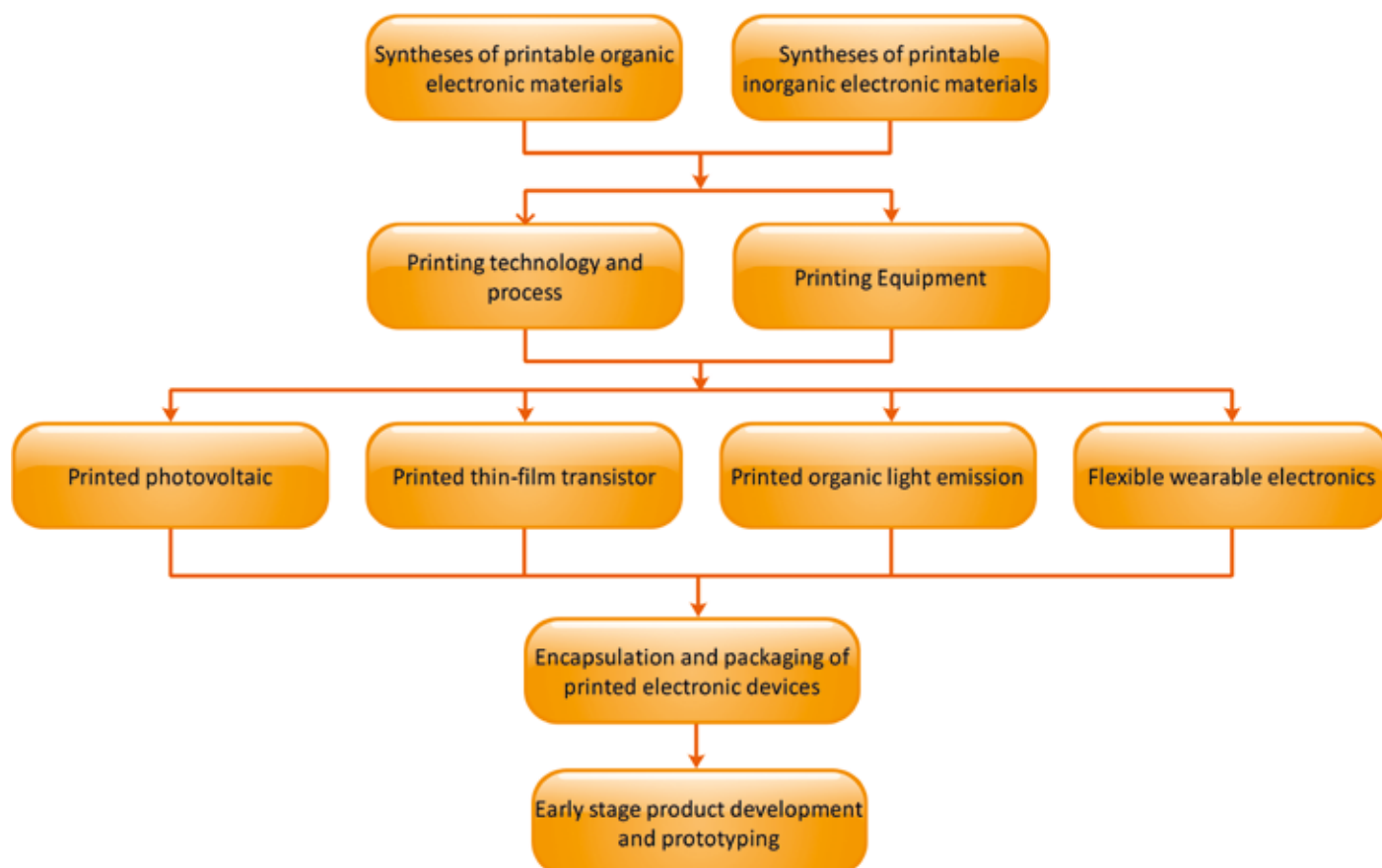
Our large research team and well-equipped laboratories enable PERC to conduct R&D in printed electronics in a wide range of topic areas. The distinctive feature of PERC different from most other research groups with SINANO or CAS is that the research is not for its own sake, but with the aim of applicable and marketable products. Our work on organic/inorganic



Blue tooth circuit on skin-like substrate

inks, printing processes and equipment, printed photovoltaic, thin-film transistors, light emitting and encapsulation, are all funnelled to 'early product development and prototyping'. In the last six years since our establishment, we have been working step by step in this direction. To name a few of our landmark achievements:

- An innovative hybrid printed metal mesh technology has been developed and successfully applied to replace ITO transparent conductors for touch panels. The innovative transparent conductive film demonstrates less than 1Ω of sheet resistance at over 88% of optical transparency and can be roll-to-roll printed. The manufacturing cost for metal mesh-based touch panels is considerably lower than their ITO counterpart. The technology has been implemented in mass manufacturing at the Chinese company O-film, which is also the world's number-one producer of touch panels for mobile phones and notebook computers. In addition, we also applied the metal mesh transparent conductor technology for replacing ITO in OPV and OLED devices.



Research themes at PERC

- We have also developed semiconductor carbon nanotube inks and metal oxide inks to print thin-film transistors (TFTs). The printed inorganic TFTs are of high charge mobility and low annealing temperatures. Logical circuits and backplane driving circuits for AMOLED have been fabricated with these TFTs.
- We have developed a series of printing processes, including photonic sintering, which enables us to print a variety of conductive inks to make hybrid circuits on plastic, textile and stretchable substrates. This technology is applied to make flexible and wearable electronics.
- Finally we are developing technologies for making MEMS-based inkjet printing heads, roll-to-roll printed perovskite solar cells and encapsulation processes for OPV and OLED, all of which are aimed towards industrial applications. A part of this work is already carried out jointly with the industry.

OPE journal: In your career, you spent about 20 years in the UK. In your opinion, how could the international cooperation between different companies and

institutes for an advancement of printed electronics technology still be improved?

Z. Cui: In scientific research and technology innovation, China has progressed very rapidly in the last ten years. The central government has put a great deal of investment in improving the research infrastructures. Research laboratories across China are much better equipped compared to 20 years ago and a lot of talented Chinese researchers who were trained and worked overseas are returning back to China – I am one of them. China is generating some very good research, as well as industrial technology innovations. The international science and technology community should not view China as a backwater anymore. For any international collaboration, China has a lot to give, instead of a lot to take. Collaboration should be on an equal basis. On the other hand, China is the world's largest market for anything and everything. Good technologies outside the country are very likely to find a market here, and this inflow of innovative technology could be better done by working with R&D groups in China like PERC.

OPE journal: Last November, PERC came up with an integrated Bluetooth chip on a skin-like flexible substrate. What new development can you tell us about this?

Z. Cui: We have identified some market opportunities for this wearable device and we are already working with a local company to set up a volume manufacturing facility. The product will enter the Chinese market this year.

OPE journal: SINANO is also a member of the OE-A. Why is it important for your institute to be a member of such an industry organisation and how do you cooperate with other members?

Z. Cui: We joined the OE-A because it is an international community and China should not be outside of it. OE-A is oriented to industrial applications and the market, which is very much in line with our goal. We are trying to learn how Europe and the rest of the world have developed or how they are currently developing PE technology for real products. As far as cooperating with other members is concerned, we have not

done anything substantial, perhaps because other members have not found a common ground to collaborate on, or for other reasons that I would like to find out about ...

OPE Journal: You are chairman of the FPE China Symposium. Can you tell us more about this conference and its significance for your activities?

Z. Cui: One of PERC's important tasks is to promote PE and to increase awareness in China. We have been doing that for the last six years. We published the first book on PE in Chinese in 2012. An English book written by PERC researchers, titled "Printed Electronics: Materials, Technologies and Applications" will be published this year. In 2010, we initiated and organised the first FPE China Symposium. Since then, the symposium has been held five times. At the first event, there were only 20 or so attendees and a handful invited speakers. Last year, we had over 200 participants and received over 80 papers.

In 2014, we also hosted the 5th International Conference on Flexible and Printed Electronics (ICFPE). I was the general chair and we had two thirds of papers and participants from China. It reflects the rapidly rising interest in PE in China. Besides the symposium, there were industrial forums on PE held in China every year as well. In March, I will chair a Sino-European flexible printed electronics forum in Shanghai, co-hosted by Messe Munich and attended



Blue tooth temperature sensor patch

by OE-A managing director Dr Klaus Hecker and LOPEC chairman Dr Wolfgang Mildner.

OPE Journal: Currently, the "OLED revolution" is entering the next phase with global players like LG and Samsung unveiling a range of new products for consumer electronics. How does PERC contribute to OLED research and do you think that other sectors of the printed electronics industry (e.g. photovoltaics, wearables and smart packaging) can be equally successful in the future as OLEDs are already today?

Z. Cui: In China, the OLED industry is booming as well. From my own memory, I can

count at least five to six production lines for OLED display panels that have been and are being constructed here. One of them is already shipping out small size panels for mobile phone manufacturers. PERC has been developing OLED technology since 2010. We have set up a complete facility to make small-size OLEDs. Our focuses are on flexible OLEDs, where we have used, for example, metal mesh transparent conductive substrates to replace ITO, fast deposition of barrier films by a PECVD process for encapsulation, new solution-processed OLED materials, inkjet printing of OLED inks and printed TFT backplane technology.

As for other areas such as photovoltaics, wearables and smart packaging, we all have people working on these areas and all are working with local companies towards developing products. I think these applications are equally important and have a very promising future because of the Internet of Things (IoT) development. One should be aware that the scale of particularly the mobile internet in China is the biggest in the world, and its relevant technology development is much more advanced than in most other countries worldwide. There will be plenty of opportunities ahead.



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